EXPRESSING CONCENTRATION

REVIEW OF VOCABULARY

- Solution—a homogeneous mixture
- Solute—the substance being dissolved
- Solvent—portion of mixture in a larger quantity; does the dissolving

SOLUTION COMPOSITION

- Dilute ⟶ relatively little solute present
- Concentration ⟶ relatively large amount of solute
- Four methods to describe solution
  - Molarity
  - Mass percent
  - Mole fraction
  - Molality

MOLARITY & MASS PERCENT

- **Molarity**
  - The number of moles of solute per liter of solution
  - Symbolized by M

$$M = \frac{moles\ of\ solute}{L\ of\ solvent}$$

- **Mass percent**
  - Percent by mass of the solute in the solution

$$Mass\ percent = \left(\frac{mass\ of\ solute}{mass\ of\ solution}\right) x\ 100\%$$

MOLE FRACTION & MOLALITY

- **Mole fraction**
  - Ratio of the number of moles of a given component to the total number of moles of solution
  - Symbolized by chi (X)

$$X_a = \frac{n_a}{n_{total}}$$

- **Molality**
  - Number of moles of solute per kilogram of solvent
  - Symbolized by m

$$m = \frac{moles\ of\ solute}{kilogram\ of\ solvent}$$

SOLUTION COMPOSITION EXAMPLE

- A solution is prepared by mixing 1.00 g ethanol (C_2H_5OH) with 100.0 g water to give a final volume of 101 mL. Calculate the molarity, mass percent, mole fraction, and molality in this solution.

❖ Molarity

$$1.00\ g\ ethanol\ x\ \frac{1\ mol\ ethanol}{46.07\ g\ ethanol} = 0.0217\ mol\ ethanol$$

$$Volume_{solution} = 101\ mL\ x\ \frac{1\ L}{1000\ mL} = 0.101\ L$$

$$M = \frac{moles\ of\ ethanol}{liters\ of\ solution} = \frac{0.0217\ mol}{0.101\ L} = 0.215\ M$$

SOLUTION COMPOSITION EXAMPLE

- Mass percent

$$Mass\ percent = \left(\frac{mass\ of\ ethanol}{mass\ of\ solution}\right) x\ 100 = \left(\frac{1.00\ g}{100.0\ g + 1.00\ g}\right) x\ 100 = 0.990\%$$

- Mole fraction

$$n_{water} = 100.0\ g\ water\ x\ \frac{1\ mol\ water}{18.0\ g\ water} = 5.56\ mol\ water$$

$$X_{ethanol} = \frac{moles\ of\ ethanol}{total\ moles} = \frac{0.0217\ mol}{0.0217\ mol + 5.56\ mol} = 0.00389\ mol$$

SOLUTION COMPOSITION EXAMPLE

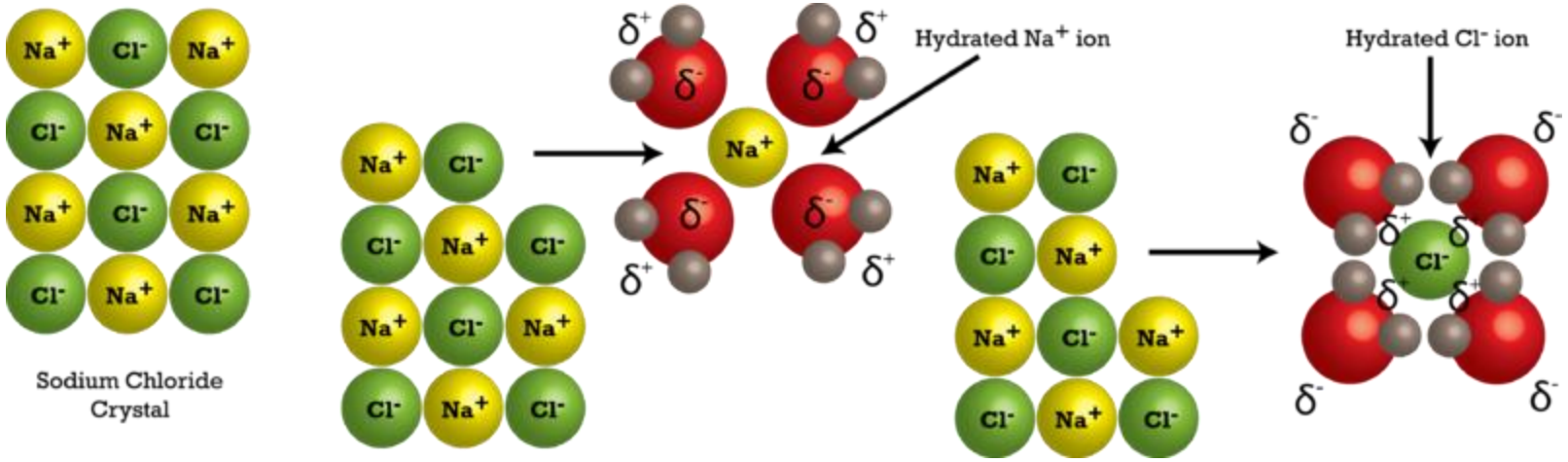
- Molality

$$Kg_{water} = 100\ g\ x\ \frac{1\ kg}{1000\ g} = 0.100\ kg$$

$$m = \frac{moles\ of\ ethanol}{kilograms\ of\ water} = \frac{0.0217\ mol}{0.100\ kg} = 0.217\ m$$

FACTORS AFFECTING SOLUBILITY

- Action of dissolving
  - Solute separated into individual components
  - Intermolecular forces have to be overcome
  - Solute and solvent interact



FACTORS AFFECTING SOLUBILITY

- **Structural effects**
  - "Like dissolves like"—solubility favored if solute and solvent have similar properties

Type of solute	Type of solvent	Solubility	Example
Ionic	Polar	Usually soluble	LiCl in H_2O
Polar	Polar	Soluble (miscible)	CH_3OH in H_2O
Nonpolar	Polar	Immiscible	C_6H_{14} in H_2O
Nonpolar	Nonpolar	Miscible	C_6H_{14} in H_2O

FACTORS AFFECTING SOLUBILITY EXAMPLE

- Discuss the solubility of each of the following solutes in carbon tetrachloride (CCl_4): ammonium nitrate, 1-pentanol, and pentane.

Solvent: CCl_4	polar	**nonpolar**
Solute:		
NH_4NO_3	**polar**	nonpolar
$C_5H_{11}OH$	**polar**	nonpolar
C_5H_{12}	polar	**nonpolar**

"Like dissolves like"

Soluble in CCl_4—pentane

FACTORS AFFECTING SOLUBILITY

- Pressure effects
  - Little effect on solubility for liquids and solids
  - More pressure above a liquid increase s the solubility of the gas in the liquid
- Temperature effects
  - Solubility generally increases with temperature
  - Exception: some solids need more energy to break solute-solute attractions than is released from these attractions